CROSS-STRAIGHT GROOVE JOINT

TECHNICAL FIELD

[0001] The invention relates to a stroking ball-type constant velocity joint, named Cross-Straight Joint and, more specifically, a constant velocity joint kinematically defined by longitudinal grooves and helical grooves for guiding movement of balls.

BACKGROUND OF THE INVENTION

[0002] A stroking ball-type constant velocity joint facilitates rotational movement between a driving shaft and a driven shaft. The stroking ball-type joint is especially useful in applications wherein the driving and driven shafts are angled with respect to one another. The stroking ball-type joint includes an inner joint member attached to one of the shafts and an outer joint member attached to the other shaft. The inner and outer joint members define grooves which cooperate to form passages. Roller balls are positioned in the passages and torque is transmitted between the shafts with the roller balls.

[0003] Stroking ball-type joints can include six-balls or eight-balls. Generally, six-ball stroking ball-type joints provide greater stroke and angle capabilities than eight-ball joints. On the other hand, eight-ball joints generally can be more compact than six-ball joints. It would be desirable to develop a stroking ball-type joint having the advantage of compactness provided by eight-ball joints with the stroke and angle capabilities of six-ball joints, at the

same time NVH (Noise Vibration and Harshness) characteristics and mechanical efficiency are improved.

SUMMARY OF THE INVENTION

[0004] The present invention provides a stroking ball-type constant velocity joint including an inner joint member defining longitudinal grooves in combination with substantially helical grooves. The grooves are formed in an outer surface of the inner joint member. The grooves cooperate with corresponding grooves formed in an inner surface of an outer joint member. The longitudinal or straight grooves are disposed along the outer surface of the inner joint member in alternating relation with respect to the helical grooves. For example, a straight groove is positioned between two helical or inclined grooves. Furthermore, adjacent helical grooves are inclined or offset in opposite directions. For example, a first helical groove extends in a left-hand direction while a second, adjacent helical groove extends in a right-hand direction.

[0005] The helical or inclined grooves of the outer joint member cooperate with the helical grooves of the inner joint member to form cross groove passages. The inclined or cross groove passages create a constant velocity plane when the joint is angled. The degree of incline of the left-hand and right-hand grooves can be smaller than that of a standard 6-ball joint design. The straight or longitudinal grooves and cross grooves cooperate to allow a greater stroke than a joint that has inclined grooves. In addition, reduction of the helix angle of the helical grooves decreases the contact stresses in the

grooves and the forces transmitted to a cage disposed between the inner and outer joint members.

[0006] Other applications of the present invention will become apparent to those skilled in the art when the following description of the best mode contemplated for practicing the invention is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0008] Figure 1 is a front planar view of an inner joint member according to an embodiment of the invention;

[0009] Figure 2 is a side planar view of the inner joint member shown in Figure 1;

[0010] Figure 3 is a bottom planar view of the inner joint member shown in Figure 1;

[0011] Figure 4 is a front planar view of an outer joint member according to an embodiment of the invention;

[0012] Figure 5 is a first cross-sectional view of the outer joint member shown in Figure 4;

[0013] Figure 6 is a second cross-sectional view of the outer joint member shown in Figure 4;

[0014] Figure 7 is a front planar view of a joint assembly according to an embodiment of the invention including the inner joint member shown in Figures 1-3 and the outer joint member shown in Figures 4-6;

[0015] Figure 8 is a first cross-sectional view of the joint assembly shown in Figure 7;

[0016] Figure 9 is a second cross-sectional view of the joint assembly shown in Figure 7; and

[0017] Figure 10 is a perspective, cross-sectional view of the joint assembly shown in Figure 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] The present invention provides a stroking ball-type constant velocity joint 10 including an inner joint member 12 having an outer surface 14 defining a plurality of radially outwardly facing grooves 16, 16a, 16b, 16c, 16d, 16e, 16f, 16g. The plurality of radially outwardly facing grooves 16, 16a, 16b, 16c, 16d, 16e, 16f, 16g include substantially longitudinal grooves 16, 16b, 16d, 16f in combination with substantially helical grooves 16a, 16c, 16e, 16g. The inner joint member 12 can also include a first end 24 and a second end 26, the grooves 16-16g can extend between the first end 24 and the second end 26.

[0019] The longitudinal grooves 16, 16b, 16d, 16f extend substantially parallel to an axis 40 of the inner joint member 12, between the first and second ends 24, 26. The inner joint member 12 can include four substantially

longitudinal grooves 16, 16b, 16d, 16f disposed along the outer surface 14 ninety degrees (90°) from one another.

[0020] The helical grooves 16a, 16c, 16e, 16g extend between the first and second ends 24, 26 offset or inclined at an angle 42 with respect to the axis 40. The inner joint member 12 includes helical grooves 16a, 16c, 16e, 16g extending in opposite rotational directions relative to one another. For example, as shown in Figures 2 and 3, the helical groove 16a extends from the second end 26 to the first end 24 at an angle 42 offset with respect to the axis 40. A first end 44 of the groove 16a is spaced further from the groove 16b than a second end 46 of the groove 16a. For convenience, the groove 16a can be characterized as a right-hand groove. The groove 16e extends between the first and second ends 24, 26 in mirrored relation to the groove 16a and, for convenience, can also be referred to as a right-hand groove.

[0021] The groove 16c can extend between the first and second ends 24, 26 at an angle 42 relative to the axis 40. The groove 16c extends in opposite rotational relation to the groove 16a, as the first end 44a of the groove 16c is spaced further from the groove 16b than the second end 46a of the groove 16c. For convenience, the groove 16c can be referred to as a left-hand groove. The groove 16g extends in mirrored relation to the groove 16c and, for convenience, can also be referred to as a left-hand groove.

[0022] As shown in Figures 1-3, each of the helical grooves 16a, 16c, 16e, 16g extend along the outer surface 14 between two longitudinal grooves 16, 16b, 16d, 16f. For example, the groove 16a extends between the grooves 16

and 16b. In addition, the grooves 16-16g can be disposed about the outer surface 14 in alternating relation. Each of the helical grooves 16a, 16c, 16e, 16g can extend between two other helical grooves extending in opposite relation. For example, the right-hand helical groove 16a extends between the left-hand grooves 16c and 16g.

[0023] The joint 10 also includes a plurality of balls 18, 18a, 18b, 18c, 18d, 18e, 18f, 18g. The balls 18-18g are individually disposed in corresponding grooves 16-16g. In operation, the balls 18-18g are moveable along the grooves 16-16g between the first and second ends 24, 26. By way of example only, the balls 18-18g can have a diameter d. Furthermore, a diameter defined by the centers of the plurality of balls 18-18g disposed in the grooves 16-16g can be D, where D is n times bigger than d.

[0024] The joint 10 also includes a cage 20 surrounding the inner joint member 12. The cage 20 defines a plurality of windows 22, 22a, 22b, 22c, 22d, 22e, 22f, 22g. Each of the windows 22-22g is disposed adjacent to a corresponding groove 16-16g. Each of the plurality of balls 18-18g pierce a respective window 22-22g and are retained in the grooves 16-16g by the cage 20. The windows 22-22g include a plurality of short windows 22, 22b, 22d, 22f and a plurality of long windows 22a, 22c, 22e, 22g. The short windows are positioned adjacent the longitudinal grooves 16, 16b, 16d, 16f. The long windows 22a, 22c, 22e, 22g are positioned adjacent the helical grooves 16a, 16c, 16e, 16g. As shown in Figure 10, a long window such as long window 22c

is circumferentially wider than a short window such as short window 22b. The axial width of the short and long windows 22-22g are the same.

[0025] Referring now to Figures 4-6, the joint 10 also includes an outer joint member 28. The outer joint member 28 surrounds the cage 20 and the inner joint member 12. The outer joint member 28 extends axially between a third end 30 and a fourth end 32. The outer joint member 28 includes an inner surface 34 defining a plurality of radially inwardly facing grooves 36, 36a, 36b, 36c, 36d, 36e, 36f, 36g extending between the third and fourth ends 30, 32.

[0026] The inwardly facing grooves 36-36g include longitudinal grooves 36, 36b, 36d, 36f and helical grooves 36a, 36c, 36e, 36g. The longitudinal grooves 36, 36b, 36d, 36f extend substantially parallel to an axis 40a of the outer joint member 28, between the third and fourth ends 30, 32. The outer joint member 28 includes four substantially longitudinal grooves 36, 36b, 36d, 36f disposed along the inner surface 34 ninety degrees (90°) from one another.

[0027] The helical grooves 36a, 36c, 36e, 36g extend between the third and fourth ends 30, 32 offset or inclined at an angle 42a with respect to the axis 40a. The outer joint member 28 includes helical grooves 36a, 36c, 36e, 36g extending in opposite rotational directions relative to one another. For example, as shown in Figures 5 and 6, the helical groove 36e extends from the third end 30 to the fourth end 32 at an angle 42a offset with respect to the axis 40a. A second end 46b of the groove 36e is spaced further from the groove 36f than a first end 44b of the groove 36e. For convenience, the groove 36e can be characterized as a right-hand groove. The groove 36a extends between the third

and fourth ends 30, 32 in mirrored relation to the groove 36e and, for convenience, can also be referred to as a right-hand groove.

[0028] The groove 36g can extend between the third and fourth ends 30, 32 at an angle 42a relative to the axis 40a. The groove 36g extends in opposite rotational relation to the groove 36e, as the first end 44c of the groove 36g is spaced closer to the groove 36f than the second end 46c of the groove 36g. For convenience, the groove 36g can be referred to as a left-hand groove. The groove 36c extends in mirrored relation to the groove 36g and, for convenience, can also be referred to as a left-hand groove.

[0029] As shown in Figures 4-6, each of the helical grooves 36a, 36c, 36e, 36g extend along the inner surface 34 between two longitudinal grooves 36, 36b, 36d, 36f. For example, the groove 36a extends between the grooves 36 and 36b. In addition, the grooves 36-36g can be disposed about the inner surface 34 in alternating relation. Each of the helical grooves 36a, 36c, 36e, 36g extends between two other helical grooves extending in opposite relation. For example, the right-hand helical groove 36a extends between the left-hand grooves 36c and 36g.

[0030] The helical grooves 16a, 16c, 16e, 16g of the inner joint member 12 individually cooperate with the helical grooves 36a, 36c, 36e, 36g of the outer joint member 28 to form cross groove passages 38a, 38c, 38e, 38g. Cross groove passages are discussed in greater detail in U.S. Patent No. 6,468,164, which is hereby incorporated by reference. For example, the groove 16a is inclined with respect to the axis 40 of the inner joint member 12 to the same

degree that the groove 36a is inclined to the axis 40a of the outer joint member 28. However, the grooves 16a and 38a extend in opposing directions such that they cross one another.

[0031] The joint assembly 10 according to the invention can have an angle capacity X and a stroke capacity Y. The joint assembly 10 is more compact than a six-ball joint having similar stroke and angle capabilities. The joint assembly 10 has greater stroke and angle capabilities than previous eight-ball joints having similar size. Furthermore, the NVH characteristics and efficiency are better than equivalent six-ball joints.

[0032] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.